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NOTES

ON SOME SPECIMENS OF

LOWER SILURIAN TRILOBITES.

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(Plates XXXI. and XXXII.)

1. Asaphus platycephalus, *with some of the legs preserved.*

This specimen was collected in the Trenton Limestone, at the city of Ottawa, about ten years ago. When discovered it was lying flat upon a thin slab of limestone, and well preserved, with the exception of the eyes, which seem to have been forced inwards by pressure from above. It was also divided into two pieces by a fissure which extended diagonally across, from the first segment of the thorax on the left side to the fifth segment on the right.

It remained in the Museum for several years without attracting particular attention, until one day, observing that the part in front of the fissure was somewhat loosely attached, I removed it, and was surprised at finding, on the underside, not only the hypostoma in place, but also what appeared to be some of the legs of the animal. As the part behind the fissure was more firmly attached to the stone, I had it cut across just behind the eighth segment by the lapidary of the Survey. The remainder of the thorax was then easily split off. The pygidium came off with difficulty and in two pieces. All the pieces were then fastened together; and we thus obtained two specimens, one of which shows the underside of the Trilobite, and the other its impression on the stone.

On the underside (Pl. XXXI. fig. 1) a broad shallow groove extends

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from the space between the two lobes of the hypostoma, where we must suppose the mouth to be situated, backwards along the median line to the pygidium. This corresponds in position to the sternum of the ordinary crustacea. The legs are arranged in eight pairs, the bases of each pair being situated exactly under one of the eight segments of the thorax, and at the sides of the sternal groove.

The legs of the first pair are better-preserved than the others. They curve forwards and can be traced to a point nearly under the outer edge of the eye, or, rather, between the eye and the outside of the head. The other seven pairs follow at the average distance of two and a half lines from each other. The eight pairs thus occupy about twenty lines of the length of the ventral surface. This is exactly the length of the thorax, measured on the upperside. This trilobite has always eight segments in the thorax; and there is thus on the underside one pair of appendages to each segment. Although some of them are very imperfect, and the portions that remain are somewhat displaced, with a little study of the specimen it can be seen that they all curve forwards, and are thus, most probably, ambulatory rather than natatory legs.

There appear to be several joints in each of these appendages; but the exact number cannot be made out. On the left side, the first four legs show very clearly that there are at least two, one at five lines from the side of the groove, and another about three lines further out. The position of each of these is indicated by a small protuberance (Pl. XXXI. fig. 1, *n*). On the right side the preserved portions of the legs are longer, and thus indicate a greater number of articulations, although they cannot be distinctly seen. I think that each leg consisted of at least four or five articulations.

On the pygidium there are three small ovate tubercles, arranged in a line, that seem to be organic (fig. 1, *d*); and if they are so, they are, perhaps, the processes to which respiratory feet were attached.

The length of the specimen is four and a half inches, and the width two and a half inches. On a side view the height of the head just behind the eyes is nine lines, and at the middle of the thorax about seven lines. The depth of the internal cavity at the back part of the head is seven lines, and at the last segment of the thorax four lines. The plane in which the legs are situated is therefore not so low down as the extremities of the pleuræ. The visceral cavity is thus about one-third less than the whole bulk of the animal (Pl. XXXII. fig. 1).

The above is all that I desire to say at present concerning this remarkable specimen. The first and all-important point to be decided is, whether or not the forms exhibited on its underside are truly, what they appear to be, locomotive organs. If this question be decided in the affirmative, it will then remain for Carcinologists and others to homologize them with the limbs of existing crustacea. It is scarcely necessary to remark, in this place, that, in view of the great zoological questions that are at present being discussed, the correct determination of the affinities of the Trilobites is of extraordinary importance.

A short notice of the specimen was drawn up and read before the Natural-History Society of Montreal in 1864. Publication, however, was delayed, partly because I hoped to obtain additional evidence, but principally because I wished to have the specimen first exhibited to the Geological Society, and examined by as many of the Fellows as possible. Feeling somewhat apprehensive that it would be difficult to persuade geologists and palæontologists into the belief of the existence of trilobitic legs by figures and descriptions alone, I thought it better to wait until the paper and the specimens could be laid before the Society at the same time.

During the six years that have elapsed, a vast number of Trilobites have passed through my hands, but nearly all of them in a fragmentary condition. Among such, I am satisfied, we may seek in vain for any traces of locomotive organs. We can only expect to find them in perfect or nearly perfect specimens. These latter, considering the prodigious multitude of these animals that must have existed in the Silurian and Devonian seas, are not abundant fossils; at least they are not so in our Canadian rocks. For example, during the twenty years that I have collected fossils, I do not believe that I have seen fifty specimens of *A. platycephalus* with with the head, thorax, and pygidium all in connexion. We have had a number of those belonging to the provincial collection cut up and polished, without any success whatever. They were not the best ones, but they were as perfect as was the subject of this notice before it was split apart. There are others in the collection which may have the underside preserved; but we do not like to sacrifice them. Although no additional evidence of the existence of limbs was discovered, several points in the structure of other parts were ascertained, which will be described further on. As Sir W. E. Logan is about visiting London, and has kindly offered to take charge of this paper, and will also take the specimens with him, I shall delay publication no longer.

2. *Discovery of the Panderian Organ* in several American species of* Asaphus.

The evidence afforded by the specimen above described, and others of which I have made sections, proves that in the genus *Asaphus* the underside was not flat, but somewhat concave. In the head, on each side of the mouth, there was a cavity like that which occurs in the existing king crab—*Limulus Polyphemus*. The position of these cavities is at c c, in Pl. XXXI. fig. 1. They are partially filled up in the specimen; but I have ascertained their depth to be about five lines in another individual of the same size. The ends of the pleuræ projected downwards a short distance below the level of the sternum. The pygidium was also concave at the sides, with a portion along the middle, holding the intestine, convex. This structure can be seen, in part, by examining the slab from which the specimen

* Dr. Volborth calls the organs in question "*die Pander'schen Organe*," a term of which I heartily approve, as, if generally adopted, it will permanently associate Dr. Pander's name with his discovery.

above noticed was split. Portions of the lower margins of the head and tail, and the extremities of some of the pleuræ, remained sticking in the stone. It can also be proved by polished sections through the head and tail of any well-preserved specimen. Such sections usually show that a portion of the crust, called the "doublure" by Barrande, all round the margin is folded under and reflected upwards, ending in a free thin edge (Pl. XXXI. figs. 2, 3, 4). The pleuræ have also a doublure, which extends upwards, nearly halfway to the median lobe of the body. In consequence of this structure the extremities of the pleuræ are hollow, exactly like those of a lobster.

In *Limulus* a similar doublure occurs; and we can see there that it is continuous with the thin membranous crust which covers the underside of the body and bears the limbs. Between the sternum of *Limulus*, with its load of ponderous legs, and the doublure there is no connexion, all round, except this fragile membrane. In consequence of this structure it often comes away with all its appendages, leaving nothing of the animal except its huge carapace, pygidium, and telson. Specimens of this great crab in this condition are common in museums.

In the genus *Asaphus*, and, no doubt, in all other Trilobites, the doublure is, as in these imperfect specimens of *Limulus*, only the remains of the integument which covered the underside and supported the sternum. These two genera, however, differ widely in other respects.

The doublure of *A. platycephalus* was figured by Dr. Bigsby so long ago as 1823, in the Geological Transactions, 2nd series, vol. i. pl. xxvii. fig. 1 *c*, among the illustrations of his paper "On the Geography and Geology of Lake Huron." The figure shows a section through the doublure on the right side, just in front of a line drawn across the head through the centres of the eyes. In the description of the figure the true character of the part in question is recognized, by the remark that "*the shelly crust of the under side joins the upper at the sides.*" It is also shown in fig. 1 *b*, on the same plate, which represents the underside of the same specimen, with the hypostoma in place*. In that paper this now famous Trilobite

* This is the second hypostoma ever figured. Barrande, in his great work on the Trilobites of Bohemia, commences the history of the organ in question, thus:—

"A. *Données Historiques.*

"1821. Le plus ancien hypostome connu, est figuré et décrit par Wahlenberg, sous le nom de *Entomostracites bucephalus* (Nov. Act. Soc. Sci. Upsal. viii. 37, pl. i. fig. 6).

"1822. Ch. Stokes découvre sous la tête d'*Asaphus platycephalus* (*Isotelus gigas*, De K.) une pièce crustacée, placée à l'entrée de l'estomac; et il la décrit dans les Transact. Géol. (nouv. sér. i. 208, pl. 27).

"La même année, le savant Américain De Kay décrit et représente le même appareil que nous retrouvons figuré par Buckland dans les *Bridgew. Treatises*, en 1837." (Barrande, Système Silurien &c. vol. i. p. 154.)

There is a difficulty about the nomenclature of this Trilobite, owing, in part, to some uncertainty as to the true dates of publication. In the later reports of our survey we have adopted the name given to it by Stokes, while most American authors call it either *Asaphus gigas* or *Isotelus gigas*. Dr. Bigsby's paper was

was first made known to science. It was named by Mr. Stokes. Very numerous figures of the doublure of different species of Trilobites may be seen in the large works of Barrande, Salter, and others; but it is described by some as a portion of the crust, folded under to give greater strength to the margins of the head and tail. This, however, is not the whole of its interpretation. It is (as above stated) a part of the underside, which, on account of its greater thickness and hardness, is usually preserved, while the more membranous and fragile portions have disappeared.

About twelve years ago, Dr. Pander discovered some small scars and tubercles on the inner surface of the doublure of the Russian Trilobite *A. expansus*; and they were afterwards described and figured by Dr. A. Volborth in several papers*. He supposes them to indicate the points of attachment of soft swimming-feet. Eichwald has also described and figured the same organs in *A. Schlotheimii*, but maintains that they are the sockets of the first segments of hard, horny, articulated, ambulatory legs†. These two distinguished naturalists have discussed the points in difference between them at length, and with their well-known ability, in the works cited below. I have discovered the same organs in three of our species—*A. platycephalus*, *A. canadensis*, and *A. megistos*. They are small rounded or ovate scars, with an elevated protuberance on one side. They are situated on the doublure, close to the anterior margins of the pleuræ. The protuberance leaves a small but distinctly marked pit in the cast of the interior, as is shown in Pl. XXXI. fig. 5. That organs of some kind were here attached, I think there can be little doubt. But what was their function? If they were legs, then *Asaphus* must have had four parallel rows of limbs beneath the thorax. If the two inner rows were ambulatory, as I suppose those of our Trilobite to have been, then the two outer rows may have been natatory, as Dr. Volborth maintains. Eichwald figures several slender articulated organs, which he supposes to be the legs of Trilobites; and indeed they resemble, not remotely, those of our specimen. For convenience of reference, I have copied his figures (Plate XXXI. fig. 6). If they are truly the same organs, he would still be, to some extent, wrong; for he thinks they were attached to the doublure.

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read February 21st, March 7th, and 21st, 1823. It is usually cited under the date of 1822. In his article on the Minerals and Fossils of Canada, published in Silliman's Journal in 1824, vol. viii. p. 84, he alludes to it thus:—"I beg to refer to three figures of large unknown trilobites, published last year in the Geological Transactions of London." I infer from this that the portion of the Transactions containing his paper was issued in 1823. De Kay's paper, in which the species was first called *Isotelus gigas*, was read before the New York Lyceum of Natural History, October 27th, 1823. It is generally quoted with the date 1824.

* (1) Deutsche Petersb. Akad. Zeitung, 1857, No. 255; (2) Verhandl. der kaiserl. miner. Gesellsch. Jahrg. 1857–58. p. 168; (3) Mém. Acad. Imp. St. Pétersbourg, tome vi. No. 2, 1863; (4) Bull. Soc. Imp. Nat. Moscou, No. 1, 1866. I have only seen the last two of these.

† Lethæa Rossica, vol. i. pt. 2. p. 1364, pl. 52. fig. 24.

3. *Are* Protichnites *and* Climactichnites *the tracks of Trilobites?*

In his description of *Protichnites*, Prof. Owen says:—"The *Limulus*, which has the small anterior pair of limbs (near the middle line) and the next four lateral pairs of limbs bifurcate at the free extremity, the last pair of lateral limbs with four lamelliform appendages, and a long slender hard tail, comes the nearest to my idea of the kind of animal which has left the impressions on the Potsdam sandstone"*. In 1862, Dr. J. W. Dawson tested this opinion by actual experiment, on a sandy beach near the mouth of the Scarborough river, on the coast of Maine. Having caught a *Limulus* he kept it alive for several days, and "tried its mode of locomotion under various conditions on the sandy shore, and preserved sketches of the markings"†. His figures and descriptions prove clearly that the tracks on the sandstone could have been made by an animal having a structure like that of *Limulus*. The grooves along the side of the track were made by the edges of the broad cephalothorax, the small pit-like impressions by the extremities of the large limbs, the transverse grooves by the lamelliform feet, and the median groove by the telson. If it be granted that *Asaphus*, in addition to its thoracic legs, possessed a set of lamellar swimming-appendages under the pygidium, then the structure of the under-surface would be sufficiently like that of *Limulus* to enable it to produce the same markings. The median groove might be made by a Trilobite with a caudal spine like that of *Megalaspis heros* (Angelin). This species is a true *Asaphus*. The large Trilobite of the Potsdam sandstone, *Dikelocephalus*, differs little in general structure from *Asaphus*, while the pygidium of several of the species evinces a tendency to become spinous around the margin. The genus *Aglaspis* (Hall) appears to me to be a Trilobite of the same group; and, moreover, the specimens figured seem to be the tail and not the head. What are supposed to be the eyes are the bases of two spines, like the one that occurs on the pygidium of *Bathyurus spiniger* (*Acidaspis spiniger*, Hall).

Dr. Dawson, after comparing all the facts, says:—"On the whole we may safely conclude that, if any of the larger primordial Trilobites were provided with walking- and swimming-feet of the type of those of *Limulus*, but differing in details of structure, they may have produced both the *Protichnites* and the *Climactichnites*." Prof. J. D. Dana, also speaking of the latter, says:—"It has been regarded as the track of a very large Gasteropod; but it is quite as probable that it was made by the clusters of foliaceous appendages of one of the great Trilobites—these appendages being its locomotive organs"‡. The following, therefore is the present state of the question:—

1. The tracks could have been made either by a *Limulus* or by a Trilobite.

* Quart. Journ. Geol. Soc. vol. viii. p. 224.
† Canadian Naturalist and Geologist, vol. vii. p. 276.
‡ Manual of Geology, p. 185.

2. No fossils of the order (*Xiphosura*) to which *Limulus* belongs have been found so low down as the Potsdam sandstone.

3. Large Trilobites occur there in abundance.

The weight of the evidence, therefore, favours the opinion that the tracks in question are those of Trilobites. It is important to bear in mind that *Protichnites* and *Climactichnites* occur together on the same slabs of sandstone. Dr. Dawson's observations clearly prove that both might have been made by an animal of the same species under different circumstances, accordingly as its walking- or its swimming-feet were made use of. Judging from the width of the tracks, I believe that several of those of both kinds on one of the slabs, now in the Museum of the Survey, were made by the same individual.

4. *On a rolled-up specimen of* Calymene senaria *filled with small ovate bodies.*

It is above stated that while seeking for additional evidence relating to the limbs of Trilobites, a number of specimens were cut up and polished. One of these was an exceedingly perfect, rolled-up *Calymene senaria*, from the Hudson-River group at Cincinnati, in Ohio.

This animal (Pl. XXXII. fig. 3) appears to have shut itself up so completely that the fine mud in which it was buried could only gain access through the small fissure at *a*, where the points of the head and tail come together. There is here a small space, within the letters, *c*, *d*, *e*, *f*, which is of a light yellowish brown. I think that neither the mud, nor even the muddy water, penetrated further. There is no trace of comminuted fossils in this space, as there is in most specimens that I have cut up. The whole of the remainder of the cavity is filled with a greenish-grey spar, with a patch in the back part of the head at *b* of a different colour. This spar holds a vast number of small ovate bodies (fig. 4), of which the greater diameter is about an eightieth of an inch, and the lesser a hundredth. They are of a lighter colour and more opaque than the matrix. When examined with a good glass, and under favourable light, they seem to float, as it were, in the spar. The hypostoma *c d*, is in place, and is here cut through. From the end of the tail, at *e*, a thin rough line runs inwards, nearly to the large spot at *f*, and is obscurely indicated thence to the end of the hypostoma at *c*. The spot *f* appears to be organic. It is of an ovate form, and has four or five obscure ribs across it at right angles to its greater diameter. There are other dark spots scattered irregularly throughout the matrix, that possibly may represent organic structures.

It is possible that the line *e f c* may represent the edge of the ventral integument cut through; for in a rolled-up trilobite this must be exactly its position. The small ovate bodies I believe to be the eggs.

EXPLANATION OF PLATES XXXI. & XXXII.

PLATE XXXI.

Fig. 1. *Asaphus platycephalus*, Stokes.—Underside, showing the legs: *a b*, suture through the doublure; *c*, *c*, cavities on each side of the hypostoma; *d*, *d*, tubercles on the pygidium; *f f*, cephalic doublure; *l*, *l*, the two lobes of the hypostoma; *m*, position of the mouth; *n*, *n*, *n*, *n*, joints in the legs.

Fig. 2. Transverse ideal section through the thorax: *a*, *b*, the doublure of the pleuræ; *p*, position of the Panderian organ. The dotted line from *b* to *b* indicates the contour of the ventral surface.

Fig. 3. Ideal section through the head, cutting off the points of the hypostoma, *l*, *l*, in a plane passing through the eyes: 1, 2, position of the 1st and 2nd pairs of legs.

Fig. 4. Section through the tail of a small specimen, showing the doublure, *f f*.

Fig. 5. Three pleuræ restored, showing the position of the Panderian organ at *p*; *a*, *b*, portion of the pleuræ removed.

Fig. 6. Supposed leg of Trilobite, figured by Eichwald: *a*, natural size; *b*, enlarged.

PLATE XXXII.

Fig. 1. *Asaphus platycephalus*.—Side view of the specimen which shows the legs, somewhat restored. The dotted line, *a b*, represents the position of the plane of the ventral surface nearly.

Fig. 2. Dorsal view of the same; the dotted lines indicate the position of the hypostoma and legs.

Fig. 3. *Calymene senaria*.—Section through the axis of the thorax: *a*, junction of head and tail; *b*, back of the head; *c d*, hypostoma; *e*, end of the tail; *f*, a body showing structure.

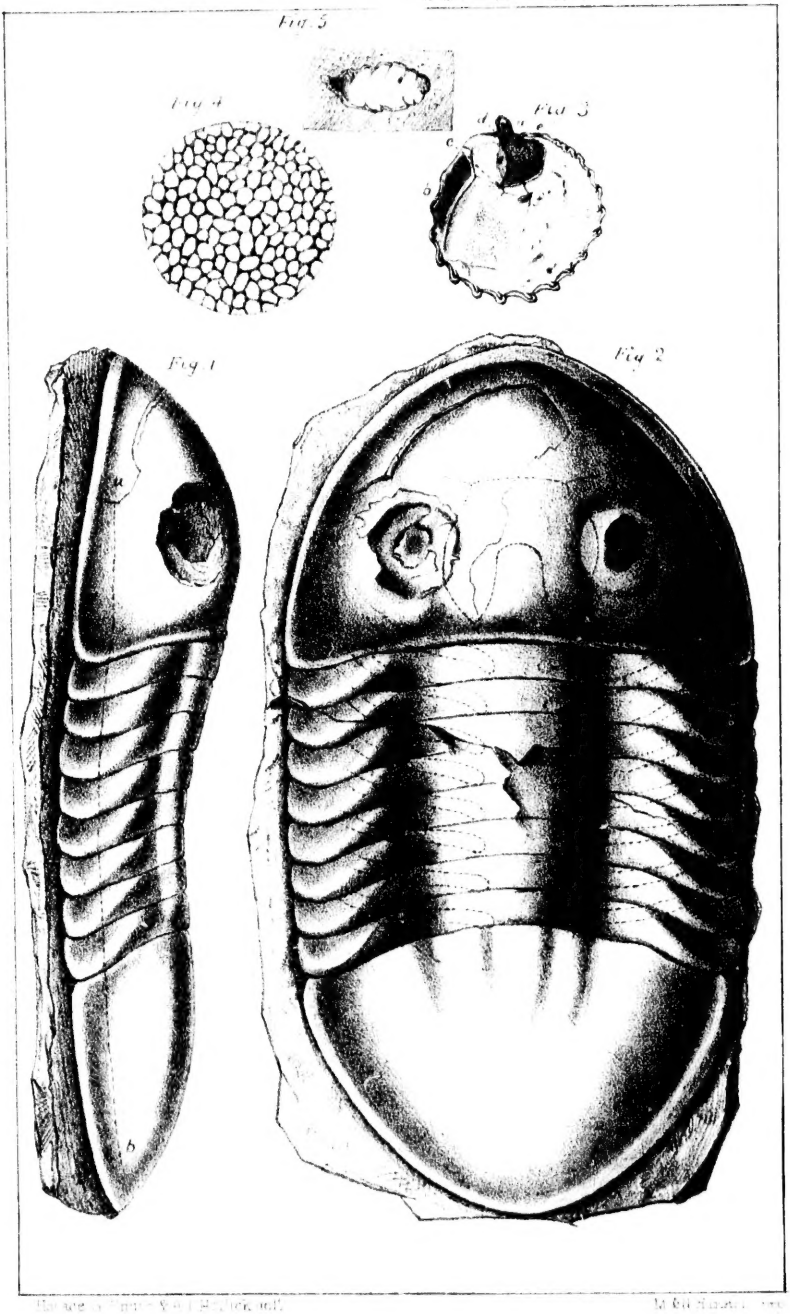
Fig. 4. A group of the small bodies in fig. 3, enlarged 8 diameters.

Fig. 5. The organic body seen at *f* in fig. 4, enlarged 3 diameters.

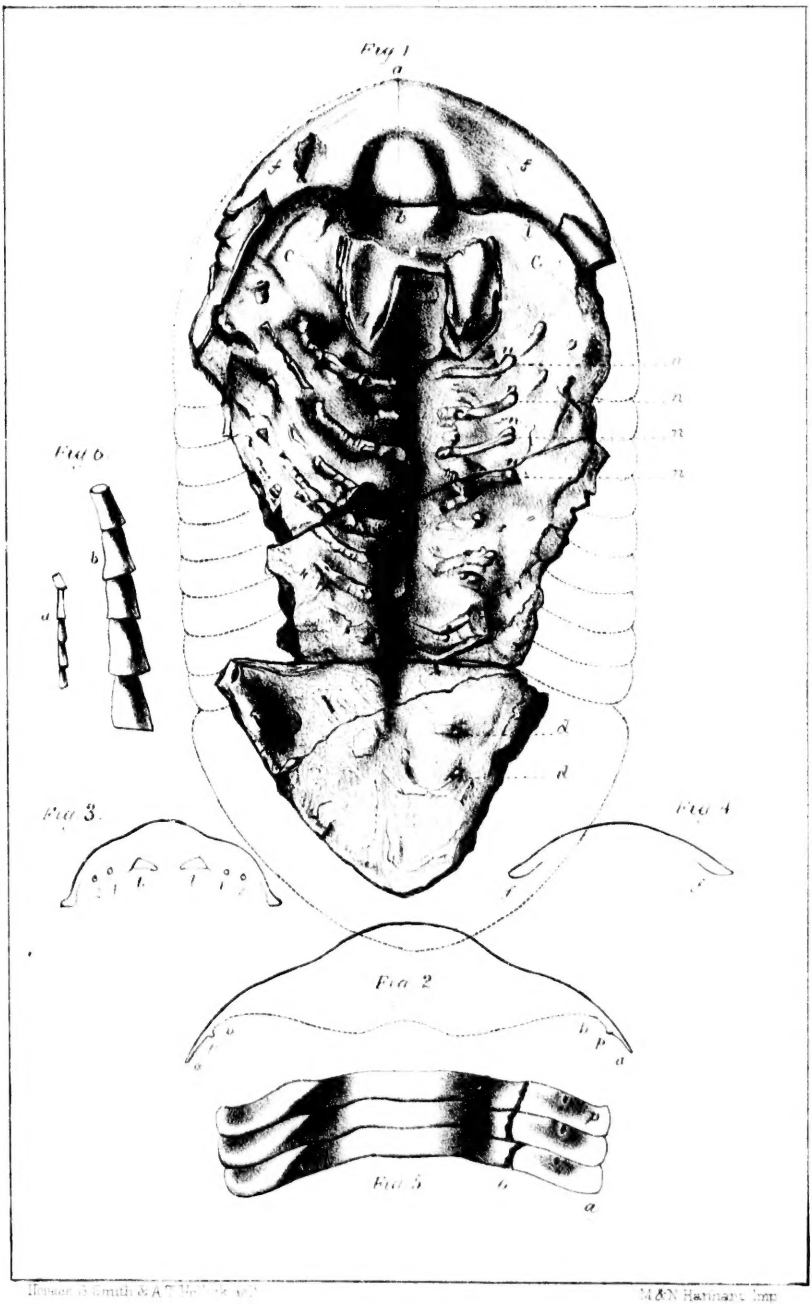
DISCUSSION.

Mr. WOODWARD had carefully examined Mr. Billings's specimen, and agreed with him in considering that there was undoubted evidence of the presence of walking-appendages under the thorax. The presence of such limbs might *à priori* have been expected; and the nature of the test suggested that the Trilobites were walking rather than swimming forms of Isopods. The branchiæ had probably been under the telson; and this would account for its large development. It was not more surprising to find highly organized Trilobites than it was to find such highly organized crustaceans as *Pterygotus*, *Eurypterus* and *Slimonia* in the same beds.

Prof. RUPERT JONES, Principal DAWSON, and Sir WM. LOGAN made some remarks, more especially on Protichnites and Climactichnites—the latter having been explained as galleries of Trilobites, by Prof. Jones, when first exhibited in England.



ASAPHUS AND CALYMENE.



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ASAPHUS PLATYCEPHALUS